

NIST TIME AND FREQUENCY BULLETIN
NIST IR 6646-10

NO. 598 OCTOBER 2007

1. GENERAL BACKGROUND INFORMATION.....	2
2. TIME SCALE INFORMATION	2
3. PHASE DEVIATIONS FOR WWVB AND LORAN-C	4
4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS	5
5. NOTES ON NIST TIME SCALES AND PRIMARY STANDARDS.....	5
6. BIBLIOGRAPHY	5

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1. GENERAL BACKGROUND INFORMATION

ACRONYMS AND ABBREVIATIONS USED IN THIS BULLETIN

ACTS	- Automated Computer Time Service		
BIPM	- Bureau International des Poids et Mesures		
CS	- Cesium Standard		
GPS	- Global Positioning System		
IERS	- International Earth Rotation Service		
LORAN	- Long Range Navigation		
MC	- Master Clock		
MJD	- Modified Julian Date		
NIST	- National Institute of Standards and Technology		
NOAA	- National Oceanic and Atmospheric Administration		
NVLAP	- National Voluntary Laboratory Accreditation Program	ns	- nanosecond
SI	- International System of Units	μs	- microsecond
TA	- Atomic Time	ms	- millisecond
TAI	- International Atomic Time	s	- second
USNO	- United States Naval Observatory	min	- minute
UTC	- Coordinated Universal Time		

2. TIME SCALE INFORMATION

The values listed below are based on data from the IERS, the USNO, and NIST. The UTC(USNO,MC) - UTC(NIST) values are averaged measurements from all available common-view GPS satellites (see bibliography on page 5). **UTC - UTC(NIST) data are on page 3.**

0000 HOURS COORDINATED UNIVERSAL TIME			
SEP 2007	MJD	UT1-UTC(NIST) (±5 ms)	UTC(USNO,MC) - UTC(NIST) (±20 ns)
6	54349	-167 ms	-3 ns
13	54356	-172 ms	-1 ns
20	54363	-175 ms	0 ns
27	54370	-182 ms	2 ns

The master clock pulses used by the WWV, WWVH, and WWVB time-code transmissions are referenced to the UTC(NIST) time scale. Occasionally, 1 s is added to the UTC time scale. This second is called a leap second. Its purpose is to keep the UTC time scale within ±0.9 s of the UT1 astronomical time scale, which changes slightly due to variations in the Earth's rotation.

NOTE: No leap second will be added at the end of December 2007

Positive leap seconds, beginning at 23 h 59 min 60 s UTC and ending at 0 h 0 min 0 s UTC, were inserted in the UTC timescale on 30 June 1972, 1981-1983, 1985, 1992, 1993, 1994, and 1997, and on 31 December 1972-1979, 1987, 1989, 1990, 1995, 1998 and 2005.

The use of leap seconds ensures that UT1 - UTC will always be held within ±0.9 s. The current value of UT1 - UTC is called the DUT1 correction. DUT1 corrections are broadcast by WWV, WWVH, WWVB, and ACTS and are printed below. These corrections may be added to received UTC time signals in order to obtain UT1.

DUT1 = UT1 - UTC =	+0.1 s beginning 0000 UTC 28 September 2006
	+0.0 s beginning 0000 UTC 22 December 2006
	-0.1 s beginning 0000 UTC 15 March 2007
	-0.2 s beginning 0000 UTC 14 June 2007

The difference between UTC(NIST) and UTC has been within ± 100 ns since July 6, 1994. The table below shows values of UTC - UTC(NIST) as supplied by the BIPM in their Circular T publication for the most recent 310 day period in which data are available. Data are given at 10 day intervals. Five day interval data are available in Circular T.

0000 Hours Coordinated Universal Time

DATE	MJD	UTC-UTC(NIST) ns
Aug. 27, 2007	54339	-3.0
Aug. 17, 2007	54329	-2.3
Aug. 07, 2007	54319	-2.4
Jul. 28, 2007	54309	-1.8
Jul. 18, 2007	54299	-2.8
Jul. 08, 2007	54289	-1.7
Jun. 28, 2007	54279	-0.2
Jun. 18, 2007	54269	2.6
Jun. 08, 2007	54259	2.1
May 29, 2007	54249	5.4
May 19, 2007	54239	7.9
May 09, 2007	54229	9.4
Apr. 29, 2007	54219	11.2
Apr. 19, 2007	54209	10.4
Apr. 09, 2007	54199	11.4
Mar. 30, 2007	54189	12.5
Mar. 20, 2007	54179	13.6
Mar. 10, 2007	54169	15.2
Feb. 28, 2007	54159	15.2
Feb. 18, 2007	54149	15.3
Feb. 08, 2007	54139	14.0
Jan. 29, 2007	54129	13.3
Jan. 19, 2007	54119	15.5
Jan. 09, 2007	54109	16.1
Dec. 30, 2006	54099	15.9
Dec. 20, 2006	54089	15.5
Dec. 10, 2006	54079	14.5

3. PHASE DEVIATIONS FOR WWVB AND LORAN-C

WWVB - The values shown for WWVB are the time differences between the time markers of the UTC(NIST) time scale and the first positive-going zero voltage crossover measured at the transmitting antenna. The uncertainty of the individual measurements is $\pm 0.5 \mu\text{s}$. The values listed are for 1300 UTC.

LORAN-C - The values shown for Loran-C represent the daily accumulated phase shift. The phase shift is measured by comparing the output of a Loran receiver to the UTC(NIST) time scale for a period of 24 h. If data were not recorded on a particular day, the symbol (-) is printed. The stations monitored are Baudette, Minnesota (8970) and Boise City, Oklahoma (9610). The monitoring is done from the NIST laboratories in Boulder, Colorado.

Note: The values shown for Loran-C are in nanoseconds.

DATE	MJD	UTC(NIST)-WWVB	UTC(NIST) - LORAN PHASE (ns)	
		(60 kHz)		
		ANTENNA PHASE (μs)	LORAN-C (BAUDETTE) (8970)	LORAN-C (BOISE CITY) (9610)
09/01/2007	54344	5.65	-80	-37
09/02/2007	54345	5.65	+27	+32
09/03/2007	54346	5.65	-13	+6
09/04/2007	54347	5.65	-23	-30
09/05/2007	54348	5.65	+4	+19
09/06/2007	54349	5.65	+5	-5
09/07/2007	54350	5.65	+20	-7
09/09/2007	54351	5.65	+205	+3
09/09/2007	54352	5.65	+517	-4
09/10/2007	54353	5.65	+9	+17
09/11/2007	54354	5.65	+69	+14
09/12/2007	54355	5.65	0	-2
09/13/2007	54356	5.65	-9	-12
09/14/2007	54357	5.65	-33	-12
09/15/2007	54358	5.65	-580	+19
09/16/2007	54359	5.65	-166	+159
09/17/2007	54360	5.65	-81	+17
09/18/2007	54361	5.65	+31	-11
09/19/2007	54362	5.65	+29	-30
09/20/2007	54363	5.65	-12	+23
09/21/2007	54364	5.65	+49	-5
09/22/2007	54365	5.65	-41	+1
09/23/2007	54366	5.65	-66	-20
09/24/2007	54367	5.65	-344	+12
09/25/2007	54368	5.65	-97	+14
09/26/2007	54369	5.65	-21	-2
09/27/2007	54370	5.65	+5	+7
09/28/2007	54371	5.65	-70	-5
09/29/2007	54372	5.65	+31	-20
09/30/2007	54373	5.65	+34	+28

4. BROADCAST OUTAGES OVER FIVE MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES OF 5 MINUTES OR MORE						PHASE PERTURBATIONS 2 ms			
Station	SEPT 2007	MJD	Began UTC	Ended UTC	Freq.	AUG 2007	MJD	Began UTC	End UTC
WWVB					60 kHz				
WWV	09-18-07	54361	1502	1534	2.5, 5, 10, 15, 20 MHz				
WWVH									

5. NOTES ON NIST TIME SCALES AND PRIMARY STANDARDS

Primary frequency standards developed and operated by NIST are used to provide accuracy (rate) input to the BIPM. NIST-F1, a cold-atom cesium fountain frequency standard, has served as the U.S. primary time and frequency standard since 1999. The uncertainty of NIST-F1 is currently about 5 parts in 10^{16} .

The AT1 scale is run in real-time by use of data from an ensemble of cesium standards and hydrogen masers. It is a free-running scale whose frequency is maintained as nearly constant as possible by choosing the optimum weight for each clock that contributes to the computation.

UTC(NIST) is generated as an offset from our real-time scale AT1. It is steered in frequency towards UTC by use of data published by the BIPM in its Circular T. Changes in the steering frequency will be made, if necessary, at 0000 UTC on the first day of the month, and occasionally at mid-month. A change in frequency is limited to no more than ± 2 ns/day. The frequency of UTC(NIST) is kept as stable as possible at other times.

UTC is generated at the BIPM using a post-processed time-scale algorithm and is not available in real-time. The parameters that we use to generate UTC(NIST) in real-time are therefore based on an extrapolation of UTC from the most recent available data.

6. BIBLIOGRAPHY

Allan, D.W.; Hellwig, H.; and Glaze, D.J., "An accuracy algorithm for an atomic time scale," *Metrologia*, Vol.11, No.3, pp.133-138 (1975).

Allan, D.W.; Davis, D.D.; Weiss, M.A.; Clements, A.; Guinot, B.; Granveaud, M.; Dorenwendt, K.; Fischer, B.; Hetzel, P.; Aoki, S.; Fujimoto, M.; Charron, L.; and Ashby, N., "Accuracy of International Time and Frequency Comparisons Via Global Positioning System Satellites in Common-view," *IEEE Transactions on Instrumentation and Measurement*, Vol. IM-34, pp.118-125, 1985.

Jefferts, S.R.; Shirley, J.; Parker, T.E.; Heavner, T.P.; Meekhof, D.M.; Nelson, C.; Levi, F.; Costanza, G.; De Marchi, A.; Drullinger, R.; Hollberg, L.; Lee, W.D.; and Walls, F.L., "Accuracy evaluation of NIST-F1," *Metrologia*, Vol. 39, pp. 321-336, (2002).

Lewandowski, W. and Thomas, C., "GPS Time transfer," *Proceedings of the IEEE*, Vol. 79, pp. 991-1000, 1991.

Heavner, T.P., Jefferts, S.R., Donley, E.A., Shirley, J.H. and Parker, T.E., "NIST F1; recent improvements and accuracy evaluations," *Metrologia*, Vol. 42, pp. 411-422, (2005).

Parker, T.E., Jefferts, S.R., Heavner, T.P., and Donley, E.A., "Operation of the NIST-F1 caesium fountain primary frequency standard with a maser ensemble, including the impact of frequency transfer noise," *Metrologia*, Vol. 42, pp. 423-430, (2005).

Weiss, M.A.; Allan, D.W.; "An NBS Calibration Procedure for Providing Time and Frequency at a Remote Site by Weighting and Smoothing of GPS Common View Data," *IEEE Transactions on Instrumentation and Measurement*, Vol. IM-36, pp. 572-578, 1987.

Table 7.1 lists parameters that are used to define UTC(NIST) with respect to our real-time scale AT1. To find the value of UTC(NIST) - AT1 at any time T (expressed as a Modified Julian Day, including a fraction if needed), the appropriate equation to use is the one for which the desired T is greater than or equal to the entry in the T_0 column and less than the entry in the last column. The values of x_{ls} , x, and y for that month are then used in the equation below to find the desired value. The parameters x and y represent the offset in time and in frequency, respectively, between UTC(NIST) and AT1; the parameter x_{ls} is the number of leap seconds applied to both UTC(NIST) and UTC as specified by the IERS. Leap seconds are not applied to AT1.

Table 7.1 $UTC(NIST) - AT1 = x_{ls} + x + y*(T - T_0)$					
Month	x_{ls} (s)	x (ns)	y (ns/d)	T_0 (MJD)	Valid until 0000 on: (MJD)
Nov 07	-33	-313092.9	-38.1*	54405	54435
Oct 07	-33	-311911.8	-38.1	54374	54405*
Sep 07	-33	-310768.8	-38.1	54344	54374
Aug 07	-33	-309587.7	-38.1	54313	54344
Jul 07	-33	-308940.0	-38.1	54296	54313
Jul 07	-33	-308408.0	-38.0	54282	54296†
Jun 07	-33	-307762.0	-38.0	54265	54282
Jun 07	-33	-30726.3	-37.9	54252	54265†
May 07	-33	-306738.7	-37.9	54238	54252
May 07	-33	-306091.0	-38.1	54221	54238†
Apr 07	-33	-304951.6	-38.3	54191	54221
Mar 07	-33	-304262.2	-38.1	54173	54191
Mar 07	-33	-303764.3	-38.3	54160	54173†
Feb 07	-33	-302691.9	-38.3	54132	54160
Jan 07	-33	-302079.1	-38.3	54116	54132
Jan 07	-33	-301501.6	-38.5	54101	54116†
Dec 06	-33	-300847.1	-38.5	54084	54101
Dec 06	-33	-300303.9	-38.8	54070	54084†
Nov 06	-33	-299799.5	-38.8	54057	54070
Nov 06	-33	-299129.7	-39.4	54040	54057†
Oct 06	-33	-298459.9	-39.4	54023	54040
Oct 06	-33	-297916.7	-38.8	54009	54023†

† Rate change in mid-month
 †† Rate change one day early
 *Provisional value